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RAPID RESPONSE RESEARCH AND DEVELOPMENT (R&D) FOR THE AEROSPACE SYSTEMS DIRECTORATE

Delivery Order 0021: Engineering Research and Technical Analyses of Advanced Airbreathing Propulsion Fuels

Subtask: T700 Biofuel Low Lubricity Endurance

Jeff Sympson

Woodward, Inc.

SEPTEMBER 2014
Interim Report

AIR FORCE RESEARCH LABORATORY
AEROSPACE SYSTEMS DIRECTORATE
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7541
AIR FORCE MATERIEL COMMAND
UNITED STATES AIR FORCE

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14. ABSTRACT
This report contains test results for the CT7/T700 biofuel low lubricity endurance test. The testing was performed on Woodward Item Number 6970-034 according to Woodward test procedure DTP-1827 Rev. A, herein referred to as DTP-1827, using a blend of renewable R-8 fuel as well as Jet-A, at a BOCLE between 0.85 and 1.00 mm wear scar.

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biofuel low lubricity endurance test

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1.0 EXECUTIVE SUMMARY

This report contains test results for the CT7/T700 Bio Fuel Low Lubricity Endurance Test. The testing was performed on Woodward Item Number 6970-034 according to Woodward test procedure DTP-1827 Rev. A, herein referred to as DTP-1827, using a blend of renewable R-8 fuel as well as Jet-A, at a BOCLE between 0.85 and 1.00 mm wear scar.

2.0 RESULTS AND DISCUSSION

2.1 Test Article

2.1.1 Pump Configuration

The production Commercial Cartridge Pump (CCP) is Item Number 6970-034 conforming to the requirements of current Woodward production drawing 6970-034 Rev NEW. The CCP in the tested mounting orientation is displayed in Appendix H Figure H-2.

The Woodward produced Test Article used for the Low Lubricity Endurance Test was the following:

Item Name	CT7/T700 Commercial Cartridge Pump
Item Number	6970-034
S/N	19366491

2.1.2 Functional Description

The Test Article is a gear pump that includes a high pressure relief valve that limits the maximum pump pressure.

2.2 Specification Requirements

2.2.1 Fuel Lubricity

The wear scar diameter shall be 0.85-1.00 mm per the proposal.

2.2.2 Test Duration

Test time was accumulated with 50 minute cycles followed by 5 minute shutdown periods for a targeted period of 400 hrs. Start and end dates of each test milestone are provided below in Table 1.

Table 1. Test Sequence and Dates

Test Section	Start Date	End Date
Pump Run-in Procedure	6 May 2014	6 May 2014
Pre-Test Inspection	2 June 2014	2 June 2014
Pre 100 hr. Test ATP/Characterization	5 June 2014	5 June 2014
100 hr. Low Lubricity Endurance Test	18 June 2014	23 June 2014
Post 100 hr. Test Performance Check per COM-852	23 June 2014	23 June 2014
Post 100 hr. Disassembly/Inspection	23 June 2014	23 June 2014
Assembly	24 June 2014	24 June 2014
Pre 300 hr. Test ATP/Characterization	24 June 2014	24 June 2014
300 hr. Low Lubricity Endurance Test	24 June 2014	18 July 2014
Post 300 hr. Test ATP/Characterization	18 July 2014	18 July 2014
Disassembly/Inspection	21 July 2014	21 July 2014

2.2.3 Success Criteria

There is no explicit pass/fail criterion for a 400-hour low lubricity test.

2.3 Test Parameters

2.3.1 Test Procedure

Bio Fuel Low Lubricity Endurance testing was performed per DTP-1827 (excluded from this report due to the proprietary nature of the material). The test was performed at Woodward Turbine Systems Environmental Test Facility (ETF) in Rockford, Illinois. Following the testing, the unit was post acceptance tested, then inspected in accordance with DTP-1827.

The mission cycle for the endurance testing is shown in Appendix I. Continuous data recording was performed per DTP-1827 Section 8.6. Steady-state data recording was performed per DTP-1827 Section 8.5.

The test fluid was a blend of renewable R-8 and Jet A as provided by UTC. The test fluid was tested for lubricity using the Ball-On-Cylinder-Lubricity-Evaluator (BOCLE) per WI-977 to measure the wear scar diameter, with limits of 0.85-1.00 mm with 1000 gm stylus. Samples of the test fluid were taken at intervals stated in DTP-1827. Only those cycles that met the requirements of >0.85 mm WSD were accredited to the cycle count.

A test checklist was initiated and signed off throughout the test to ensure that the proper steps were taken to perform the test correctly (see Appendix C). An equipment list and event log were generated and are provided in Appendix C. Photos of the test set up were taken and are included in Appendix D – Setup Photographs. After reassembly, the pump was tested per COM-852. The pre and post-test pump performance data is included in Appendix A. Post inspection reports and photos are included in Appendix F.

The Low Lube test sequence was per DTP-1827. The general sequence and dates of testing performed are shown in Table 1.

2.3.2 Test Procedure Deviations

A test cell heat exchanger leaked at approximately 60 hours into the 300-hour portion of the test. Heat exchanger external leakage resulted in the loss of all conditioned test fuel and 20 gallons of cooling fuel. The conditioned fuel loss resulted in a loss of both inlet and discharge pressures to the test article. Review of the test data indicates that the pump operated for approximately four hours without inlet pressure before being discovered. Per standard Woodward procedures, the pump was removed, fully disassembled, inspected, reassembled and functionally tested in order to either substantiate or refute further reliable performance, and thus, further testing.

The post heat exchanger leak pump ATP provided supporting evidence of a normal operational pump with the exception that the HPRV piston was hanging up in the sleeve. As such, the pump did not meet the HPRV cracking pressure check portion of the test (see Appendix G Post 177 hr ATP Test Points 2 and 6). Although the HPRV is a static device and did not crack during any portion of the low-lube test, the HPRV was removed from the pump and sent to Woodward's Materials Lab for further analysis. The HPRV was replaced, and the pump passed the subsequent ATP.

The heat exchanger was replaced and new fuel was added to the system and conditioned to the required lubricity as determined by BOCLE testing. The mission cycle computer was reset from

the time left off (182 hrs) to 177 hours due to the fact that 177 hours marked the last point at which the test cell was observed to be operating normally.

2.4 Low Lubricity Test Results

2.4.1 Fuel Lubricity

An "out-of-the-barrel" pre-test fuel sample was taken and the fuel lubricity was 0.76 mm wear scar diameter (WSD). The test fuel was subsequently conditioned using a clay filter and after the conditioning the Pre-test fuel sample had a WSD of 0.97.

Average lubricity (WSD) during the 400 hr test was 0.93 mm with a minimum of 0.85 and a maximum of 0.97mm. Fuel lubricity test results are shown in Appendix E Table E-5.

2.4.2 Pre-Test ATP

Piece part critical inspections were performed per Appendix A of DTP-1827 prior to the testing. The inspection record sheets are shown in Appendix B. The Test Article was assembled per the applicable assembly procedure.

The Test Article was performance tested per COM-852. The pre-performance values for the testing were all within the specified limits of COM-852. The pre-test performance data is summarized in Table 3 and a copy of the data sheet is included in Appendix A.

2.4.3 Post Test Inspections

The Test Article was performance tested per COM-852 at the conclusion of testing. The values were all within the specified limits of COM-852. The post-test performance data is in Appendix A. A comparison of the pre test fuel flow schedule to the post test schedule is shown in Table 2.

Total flow and start flow decreased 6.53% and 13.08% respectively but still exceeded the required total flow and start flow by 10.37% and 9.41%, respectively.

The rest of the parameters were tested to have minimal degradation.

Table 2. Performance Summary (COM-852 Data)

Pre/Post eCOM-852 Data Summary							
DTP-1827 Bio Fuel Low Lubricity Endurance Test							
Pump I/N	6970-034						
Pump S/N	19366491						
Test Point	**Description**	**Limits**	**Units**	**Pre Test**	**Post 400 hrs**	**Delta**	**%**
1.1	Total Flow, Intermediate Speed	3.76 - 6	gpm	4.44	4.15	-0.29	-6.53
2	HPRV Max Pressure, Int. Speed	900 - 1070	psid	1054	1018	-36	-3.42
3.1	HPRV Reseat Flow	3.5 - 6.26	gpm	4.4	4.12	-0.28	-6.36
4.1	T/O Total Flow	8.5 - 11	gpm	10.26	9.99	-0.27	-2.63
5.1	Flow near HPRV Cracking Pressure	7.98 - 11.52	gpm	10.13	9.88	-0.25	-2.47
6	HPRV Max Pressure, T/O	900 - 1120	psid	973	999	26	2.67
7.1	HPRV Reseating Total Flow	8.24 - 11.26	gpm	10.24	9.99	-0.25	-2.44
8.1	Start Flow	0.85 - 1.5	gpm	1.07	0.93	-0.14	-13.08
9.1	Max Flow Check	8.03 - 11	gpm	9.49	9.21	-0.28	-2.95
10.1	External Leakage	0	drops/min	0	0	0	0.00
10.2	Overboard Leakage	0	drops/min	0	0	0	0.00
11	Breakaway Torque	0 - 15	lb-in	8	6	-2	-25.00

2.4.4 Bearings

Post test inspections of the bearings showed fair polishing of the bearing faces (see inspection entries in Appendix B) which is more than what is expected in normal operation but is expected in extreme low lube operating conditions. Light polishing was observed after 112 hours of testing, which is also comparable to what has been demonstrated in past tests. Appendix F Images 1 and 2 show the floating and stationary bearings pre/post testing.

Pre and post test inspection results (see Table 3 and Appendix B) show that all variations in measurements are within measurement repeatability. The positive changes documented are within tool accuracy specifications. Therefore, it can be concluded that there were no observable dimensional changes on the bearings since no negative dimensional change was observed.

Table 3. Bearing Pre and Post Test Inspections

			Inspection Data		Δ
			Pre Test	Post Test	
Floating Bearing	Drive 1401-1175	Height	.3632	.3633	.0001
		ID	.6954	.6959	.0005
	Driven 1401-1176	Height	.3629	.3631	.0002
		ID	.6954	.6958	.0004
Stationary Bearings 1401-1174	Drive	Height	.5399	.5400	.0001
		ID	.6953	.6960	.0007
	Driven	Height	.5399	.5400	.0001
		ID	.6953	.6959	.0006

2.4.5 Gears

Gear wear was negligible. Table 4 shows that all variations in measurements were within measurement repeatability, most of which have no observed variation. The gear teeth showed some polishing on the working side of the teeth (see Appendix F Image 3) but the profiles remained within new part limits. After 112 hours, minimal cavitation was observed on some of the gear teeth. Regardless of conditions, this is a familiar observation among gear pumps.

No abnormalities were discovered during dimensional or visual inspection that were atypical for a low lubricity test. The wear observed was rather comparable to wear seen from previous testing.

Table 4. Gear Pre and Post Test Inspections

		Inspection Data		Δ
		Pre Test	Post Test	
Drive Gear 1445-1135	OD	1.25605	1.25605	0.0
	Width	.3752	.3752	0.0
	Front Journal OD	.6942	.6941	-.0001
	Rear Journal OD	.6941	.6940	-.0001
Driven Gear 1445-1135	OD	1.2561	1.2561	0.0
	Width	.3752	.3752	0.0
	Front Journal OD	.6941	.6941	0.0
	Rear Journal OD	.6941	.6941	0.0

2.4.6 Housing

Both the drive and driven bores of the pump housing obtained "gear wipe" along the entire diameter by the end of 112 hours of testing. This is due to maintaining a constant inlet pressure of 30 psig throughout the test. Normally only the inlet side of the housing bores would get wiped during the green run and normal operation but the high inlet pressure at low speed conditions loads the gears toward the discharge side of the housing so wiping is observed on the discharge side as well.

2.4.7 HPRV

Immediately following the test cell heat exchanger leak at 177 hours, the test article was acceptance tested per COM-852. The pump functioned normally for most of the test but the HPRV did not open during the cracking pressure test. The HPRV was removed from the pump and observed to have higher than normal friction (the piston did not move freely within the valve).

The HPRV was analyzed further in Woodward's Materials lab. The piston was pressed out of the sleeve and the visual inspection indicated that there were fuel deposits in the areas of matched clearance to the valve. No deposits were observed in locations without mating material. Scanning Electron Microscope inspection of the piston indicated that the deposits were organic and carbon based. Fourier Transform Infrared Spectroscopy was used in an attempt to identify the chemical composition of the deposit, but the results were inconclusive.

After completion of the post-400 hour acceptance test (the HPRV functioned normally), the second HPRV was disassembled for inspection. Deposits similar to those found on the first HPRV piston were observed. No further inspections have been conducted on the second valve.

3.0 CONCLUSION

The CT7/T700 Commercial Cartridge Pump (CCP) was tested to the agreed-to requirements between UTC and Woodward. A wear scar between 0.85 and 1.0 mm was maintained throughout the test and a full 400 hours were completed.

Comparing the pre and post-test performance data indicate the pump remained within operational limits. Inspection results showed slight evidence of wear, particularly in the bearing and housings but the dimensional analysis revealed all hardware remained within limits. With the exception of the HPRV performance test during replacement of the heat exchanger, the test article met all test requirements of COM-852 before and after the endurance test. There were no signs of wear or damage that affected the proper operation of the unit.

Post test acceptance testing of the unit per COM-852 revealed a decrease in start flow of approximately 13.08%, which was still 9.41% above min ATP limit. Max flow showed degradation of 6.53%, but showed 10.37% margin.

Appendix A

Pre and Post Test Performance Checks

Pre-Test COM-852, CCP Acceptance Test

WOODWARD GOVERNOR COMPANY
ROCKFORD, IL
CAGE 66503

COM-852
ECL: D
PAGE : 1 OF 1

Desc: COM - CCP ACCEPTANCE TEST PROCEDURE
Date: 22-JUL-2014
IMTPC - TEST SPECIFICATION RESULTS PRINT REPORT

Serial No: 19366491 Run No: 2 Work Order: 876961 Item No: 6970-034
Current Status: A Run Status: P Test Type: AS Test Date: 05-JUN-2014

Test Point		Record	Units	Formula Tag	Min	Value	Max	Pass Fail
1.0	Total Flow Rate Check							
1.1	Record Qtotal	Qtotal	gpm	QTOT_1	3.76	4.44	6.00	P
2.0	HPRV Total Flow Bypass	(Ps-Pb1)	psid		900	1054	1070	P
3.0	HPRV Reseating Check							
3.1	Record Qtotal	Qtotal	gpm		4.18 (Calc)	4.40	4.70 (Calc)	P
4.0	Total Flow Rate Check							
4.1	Record Qtotal	Qtotal	gpm	QTOT_2	8.50	10.26		P
5.0	HPRV Near Cracking Pressure Check							
5.1	Record Qtotal	Qtotal	gpm		9.74 (Calc)	10.13	10.78 (Calc)	P
6.0	HPRV Total Flow Bypass	(Ps-Pb1)	psid		900	973	1120	P
7.0	HPRV Reseating Check							
7.1	Record Qtotal	Qtotal	gpm		10.00 (Calc)	10.24	10.52 (Calc)	P
8.0	Starting Flow Rate Check							
8.1	Record Qtotal	Qtotal	gpm		0.85	1.07	1.50	P
9.0	Max Flow Check							
9.1	Record Qtotal	Qtotal	gpm		8.03	9.49		P
10.0	Leakage Check							
10.1	Record External Leakage	Ext Leakage	drops/min		0.0	0.0	0.0	P
10.2	Record OBD Leakage	OBD Leakage	drops/min		0.0	0.0	0.0	P
11.0	Breakaway Torque Check	Tq	lb_in			8	15	P

The following criteria were used to run this report:
Serial No: 19366491
Run Number: 2
Status: A
Run Type: AS
Order By: 1

****
* End of IMTPC *
****

Post 400 hr Test COM-852, CCP Acceptance Test

WOODWARD GOVERNOR COMPANY
ROCKFORD, IL
CAGE 66503

COM-852
ECL: D
PAGE : 1 OF 1

Desc: COM - CCP ACCEPTANCE TEST PROCEDURE
Date: 22-JUL-2014
IMTPC - TEST SPECIFICATION RESULTS PRINT REPORT

Serial No: 19366491 Run No: 7 Work Order: 2306635 Item No: 6970-034
Current Status: A Run Status: P Test Type: AR Test Date: 18-JUL-2014

Test Point		Record	Units	Formula Tag	Min	Value	Max	Pass Fail
1.0	Total Flow Rate Check							
1.1	Record Qtotal	Qtotal	gpm	QTOT_1	3.76	4.15	6.00	P
2.0	HPRV Total Flow Bypass	(Ps-Pb1)	psid		900	1018	1070	P
3.0	HPRV Reseating Check							
3.1	Record Qtotal	Qtotal	gpm		3.89 (Calc)	4.12	4.41 (Calc)	P
4.0	Total Flow Rate Check							
4.1	Record Qtotal	Qtotal	gpm	QTOT_2	8.50	9.99		P
5.0	HPRV Near Cracking Pressure Check							
5.1	Record Qtotal	Qtotal	gpm		9.47 (Calc)	9.88	10.51 (Calc)	P
6.0	HPRV Total Flow Bypass	(Ps-Pb1)	psid		900	999	1120	P
7.0	HPRV Reseating Check							
7.1	Record Qtotal	Qtotal	gpm		9.73 (Calc)	9.99	10.25 (Calc)	P
8.0	Starting Flow Rate Check							
8.1	Record Qtotal	Qtotal	gpm		0.85	0.93	1.50	P
9.0	Max Flow Check							
9.1	Record Qtotal	Qtotal	gpm		8.03	9.21		P
10.0	Leakage Check							
10.1	Record External Leakage	Ext Leakage	drops/min		0.0	0.0	0.0	P
10.2	Record OBD Leakage	OBD Leakage	drops/min		0.0	0.0	0.0	P
11.0	Breakaway Torque Check	Tq	lb_in			6	15	P

The following criteria were used to run this report:
Serial No: 19366491
Run Number: 7
Status: A
Run Type: AR
Order By: 1

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* End of IMTPC *
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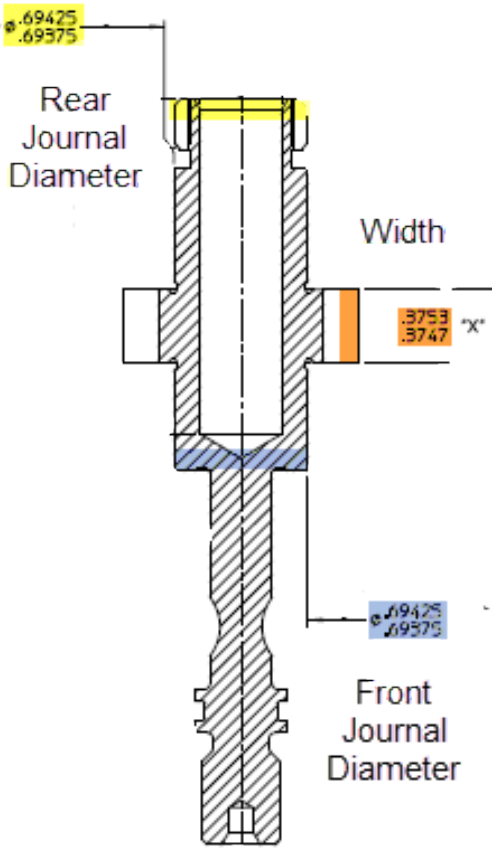
Appendix B

Pre and Post Test Inspection Data
DTP-1827 Appendix A Inspections

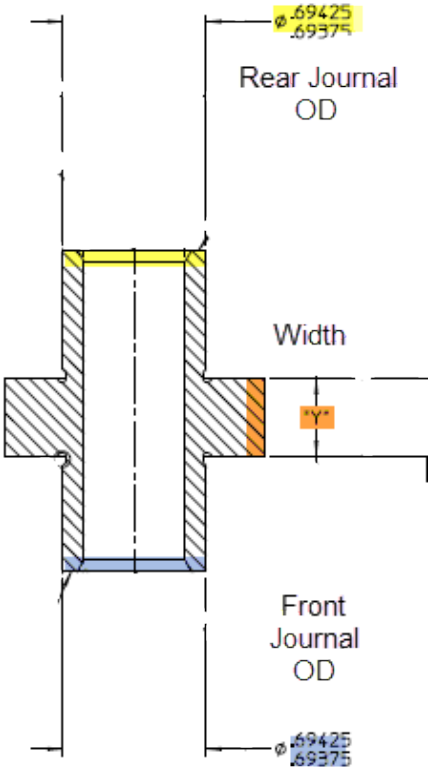
Pre-Test Inspection Data

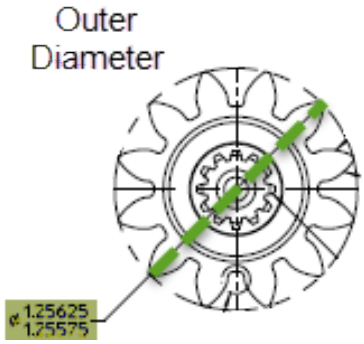
Measured Dimensions of Bearings and Gears

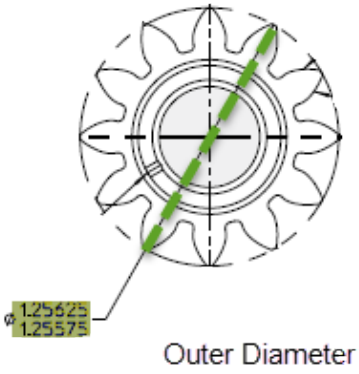
Drive Gear



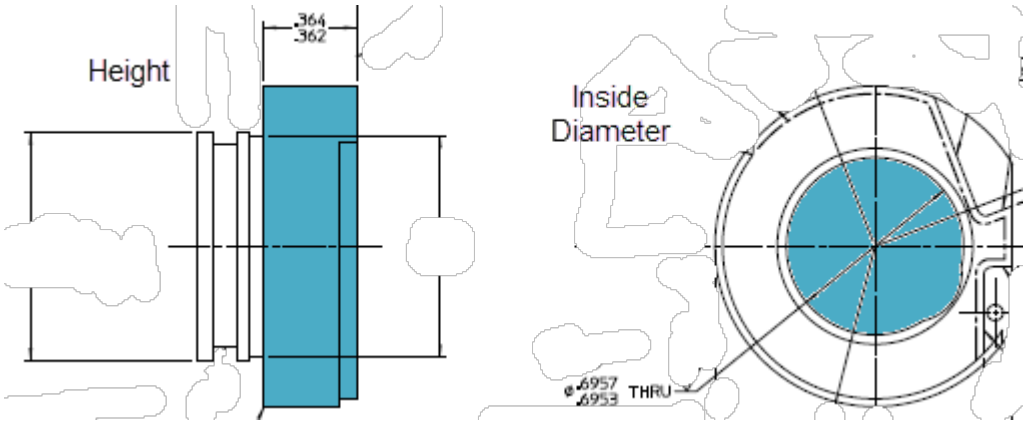
Driven Gear



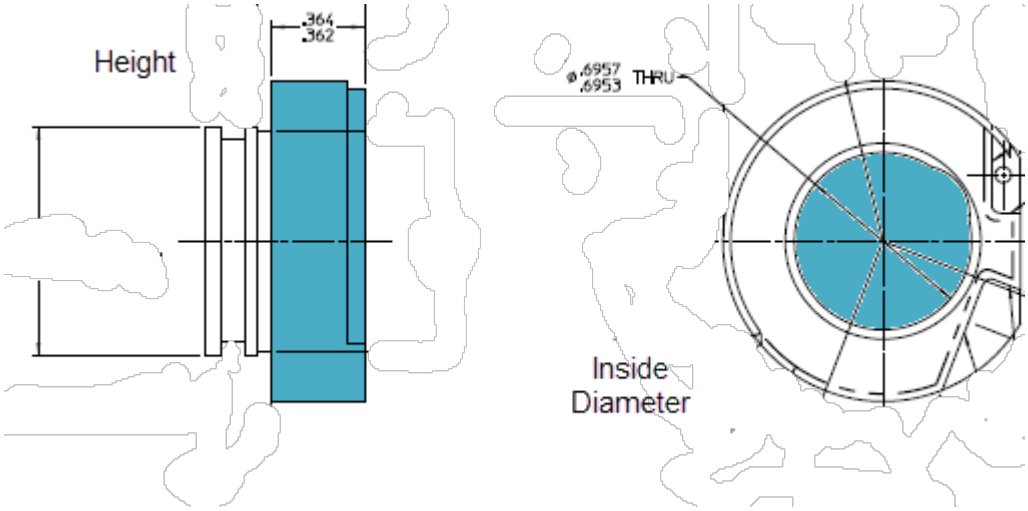




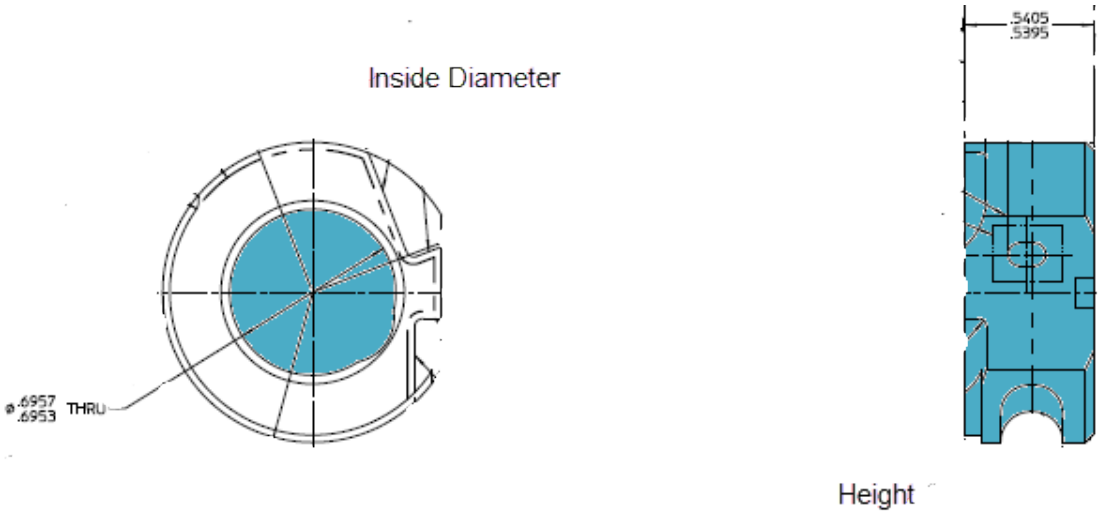
Drive Floating Bearing



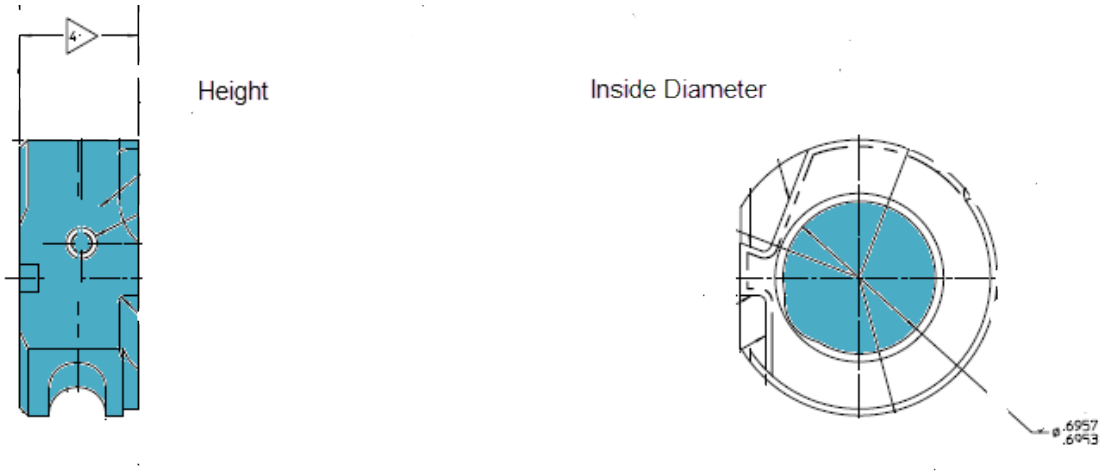
Driven Floating Bearing



Drive Stationary Bearing



Driven Stationary Bearing



APPENDIX A – Critical Inspection Record – PRE-TEST

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
N/A	Breakaway Torque	8	Jason Long 2014-05-06
Packing			
Ps Discharge (182748)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
Vapor Vent (182650)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
Overboard Drain (182650)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
Cartridge Seal (182574)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
Drive Floating Bearing (182625)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
Driven Floating Bearing (182625)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
HPRV (182748)	Visual	No discrepancies	ErinRay Meyer 2014-06-02

CRITICAL INSPECTION RECORD – PRE-TEST

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
Springs			
Floating Bearing Springs (1520-1423)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
HPRV Spring (1524-646)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
Bearings/Gears			
Drive Floating Bearing (1401-1175)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
	Inner Diameter	0.6954	Craig Rolander 2014-05-28
	Height	0.3632	Craig Rolander 2014-05-28
Driven Floating Bearing (1401-1176)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
	Inner Diameter	0.6954	Craig Rolander 2014-05-28
	Height	0.3629	Craig Rolander 2014-05-28
Drive Stationary Bearing (1401-1174)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
	Inner Diameter	0.6953	Craig Rolander 2014-05-28
	Height	0.5399	Craig Rolander 2014-05-28
Driven Stationary	Visual	No discrepancies	ErinRay Meyer 2014-06-02

CRITICAL INSPECTION RECORD – PRE-TEST

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
Bearing (1401-1174)	Inner Diameter	0.6953	Craig Rolander 2014-05-28
	Height	0.5399	Craig Rolander 2014-05-28
* Drawing Limits on all bearing inner diameters are .6952" - .6957"			
Drive Gear (1445-1135)	Visual (Including Journal and Face Finishes)	No discrepancies	ErinRay Meyer 2014-06-02
	Outer Diameter	1.25605	Steve Dietrich 2014-05-29
	Width	0.3752	Steve Dietrich 2014-05-29
	Front Journal OD	0.6942	Steve Dietrich 2014-05-29
	Rear Journal OD	0.6941	Steve Dietrich 2014-05-29
Driven Gear (1445-1135)	Visual (Including Journal and Face Finishes)	No discrepancies	ErinRay Meyer 2014-06-02
	Outer Diameter	1.2561	Steve Dietrich 2014-05-29
	Width	0.3752	Steve Dietrich 2014-05-29
	Front Journal OD	0.6941	Steve Dietrich 2014-05-29
	Rear Journal OD	0.6941	Steve Dietrich 2014-05-29
* Drawing Limits on all outer gear diameters are 1.25575" – 1.25625"			
* Drawing Limits on all gear widths are .3747" - .3753"			
* Drawing Limits on all journal outer diameters are .69375" - .69425"			
Seals			

CRITICAL INSPECTION RECORD – PRE-TEST

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
Cartridge Seal (3051-5051)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
Trapezoidal Seal (3051-5052)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
HPRV			
Sleeve (5225-1254)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
Piston (5225-1254)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
Spring Seat (4100-1179)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
Housing			
Pump Cover (3550-1584)	Visual	No discrepancies	ErinRay Meyer 2014-06-02
Pump Housing (4034-1630)	Visual	No discrepancies	ErinRay Meyer 2014-06-02

Post 400 hr Inspection Data

CRITICAL INSPECTION RECORD – POST-TEST 400 hrs

Test Article I/N: 6970-034			Test Article S/N: 19366491
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
N/A	Breakaway Torque	6	Jason Long 2014-07-18
Packing			
Ps Discharge (182748)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
Vapor Vent (182650)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
Overboard Drain (182650)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
Cartridge Seal (182574)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
Drive Floating Bearing (182625)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
Driven Floating Bearing (182625)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
HPRV (182748)	Visual	No discrepancies	ErinRay Meyer 2014-07-21

CRITICAL INSPECTION RECORD – POST-TEST 400 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
Springs			
Floating Bearing Springs (1520-1423)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
HPRV Spring (1524-646)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
Bearings/Gears			
Drive Floating Bearing (1401-1175)	Visual	Fair polishing	ErinRay Meyer 2014-07-21
	Inner Diameter	0.6954	Craig Rolander 2014-07-22
	Height	0.3632	Craig Rolander 2014-07-22
Driven Floating Bearing (1401-1176)	Visual	Fair polishing	ErinRay Meyer 2014-07-21
	Inner Diameter	0.6954	Craig Rolander 2014-07-22
	Height	0.3631	Craig Rolander 2014-07-22
Drive Stationary Bearing (1401-1174)	Visual	Fair polishing	ErinRay Meyer 2014-07-21
	Inner Diameter	0.6954	Craig Rolander 2014-07-22
	Height	0.5400	Craig Rolander 2014-07-22
Driven Stationary Bearing (1401-1174)	Visual	Fair polishing	ErinRay Meyer 2014-07-21
	Inner Diameter	0.6953	Craig Rolander 2014-07-22
	Height	0.5401	Craig Rolander 2014-07-22
* Drawing Limits on all bearing inner diameters are .6952" - .6957"			

CRITICAL INSPECTION RECORD – POST-TEST 400 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
Drive Gear (1445-1135)	Visual (Including Journal and Face Finishes)	Minimal cavitation and light markings on journals	ErinRay Meyer 2014-07-21
	Outer Diameter	1.25605	Steve Dietrich 2014-07-23
	Width	0.3752	Steve Dietrich 2014-07-23
	Front Journal OD	0.6941	Steve Dietrich 2014-07-23
	Rear Journal OD	0.6940	Steve Dietrich 2014-07-23
Driven Gear (1445-1135)	Visual (Including Journal and Face Finishes)	Minimal cavitation and light markings on journals	ErinRay Meyer 2014-07-21
	Outer Diameter	1.2561	Steve Dietrich 2014-07-23
	Width	0.3752	Steve Dietrich 2014-07-23
	Front Journal OD	0.6941	Steve Dietrich 2014-07-23
	Rear Journal OD	0.6941	Steve Dietrich 2014-07-23
Both Gears	Gear Tooth Profile per Drawing (1445-1135) Instructions	Inspect all teeth; both faces, and overlay front and back face inspection charts for each tooth. Provide inspection records to engineering.	ErinRay Meyer 2014-07-21
* Drawing Limits on all outer gear diameters are 1.25575" – 1.25625"			
* Drawing Limits on all gear widths are .3747" - .3753"			
* Drawing Limits on all journal outer diameters are .69375" - .69425"			

CRITICAL INSPECTION RECORD – POST-TEST 400 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
Seals			
Cartridge Seal (3051-5051)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
Trapezoidal Seal (3051-5052)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
HPRV			
Sleeve (5225-1254)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
Piston (5225-1254)	Visual	Organic deposit on several edges (new HPRV)	ErinRay Meyer 2014-70-21
Spring Seat (4100-1179)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
Housing			
Pump Cover (3550-1584)	Visual	No discrepancies	ErinRay Meyer 2014-07-21
Pump Housing (4034-1630)	Visual	The housing wipe extends the entire inside diameter of each bore.	ErinRay Meyer 2014-07-21

Appendix C

Test Log Sheets

Event Log

Event Log

Project Number: 130876	DTP Number: DTP-1827	Test Stand/Cell: 25a
Test Article I/N: 6970-034	Test Article S/N: 19366491	

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
2014/06/13	12:30	TMM		Took fuel sample.
2014/06/13	14:40			Ran steady state with clay filter on for 0.30 min. Took fuel sample.
2014/06/17	07:25	TMM		Installed test article in cell. Ran 2 mission cycles and took fuel sample.
2014/06/17	12:45	TMM		Opened clay filter for 0.10 min, ran 2 mission cycles and took fuel sample.
2014/06/18	15:00	TMM	00H:00M	Started test, took fuel sample #1 and a sample to be saved until the report is written.
2014/06/18	15:30	TMM	00H:30M 3 Acc Cycles	Took fuel sample #2.
2014/06/18	19:30	JW	04H:30M 27 Acc Cycles	Took fuel sample #3.
2014/06/18	23:30	TB	08H:30M 39 Acc Cycles	Took fuel sample #4.
2014/06/19	02:30	TB	12H:30M 57 Acc Cycles	Took fuel sample #5.
2014/06/19	05:40	TMM	14H:40M 75 Acc Cycles	Test running good, transferred data.
2014/06/19	07:15	TMM	16H:15M 84 Acc Cycles	Took fuel sample #6.
2014/06/19	13:15	TMM	22H:15m 121 Acc Cycles	Checked test, running good.
2014/06/19	19:36	JW	29H:36M 154 Acc Cycles	Took fuel sample #7.

Event Log

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
2014/06/20	06:31	TMM	39H:22M 214 Acc Cycles	Checked test, running good. Transferred data.
2014/06/20	07:31	TMM	40H:32M 220 Acc Cycles	Took fuel sample #8.
2014/06/20	10:40	TMM	43H:38M 237 Acc Cycles	Ran clay filter for 10 min, took fuel sample #9.
2014/06/20	20:15	JW	53H:11M 289 Acc Cycles	Took fuel sample #10.
2014/06/21	06:30	TMM	63H34M 354 Acc Cycles	Checked test and transferred data, Ran clay filter for 0.3 min.
2014/06/21	07:35	TMM	64H:29M 350 Acc Cycles	Took fuel sample #11.
2014/06/21	19:50	TB	76H:48M 417 Acc Cycles	Took fuel sample #12.
2014/06/22	08:30	BW	88H:49M 482 Acc cycles	Took fuel sample #13.
2014/06/22	19:08	KLK	100H:02M 540 Acc cycles	Took fuel sample #14.
2014/06/23	06:15	TMM	111H:14M 604 Acc cycles	Checked test and transferred data Took fuel sample #15.
2014/06/23	06:28	TMM	111H:29M 605 Acc Cycles	Shut test down for post 600 cycle inspections. Took post test fuel sample to be saved until the report is written.
2014/06/24	12:15	TMM		Received and installed test article from Post 100 hr inspections. Opened clay filter for 5 min and ran 2 cycles, took fuel sample #16.
2014/06/24	15:35	TMM		Opened clay filter for 20 min, took fuel sample #17.

Event Log

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
2014/06/24	16:20	TMM	111H:29M 605 Acc Cycles	Started second part of DTP-1827. Took pre test sample be saved until the report is written.
2014/06/25	06:20	TMM	125H:28M 681 Acc Cycles	Checked test and transferred data Took fuel sample #18.
2014/06/25	18:28	TMM	137H:37M 747 Acc Cycles	Took fuel sample #19.
2014/06/26	06:15	TMM	149H:16M 810 Acc Cycles	Checked test and transferred data Took fuel sample #20.
2014/06/26	18:17	JW	161H:14M 875 Acc Cycles	Took sample # 21.
2014/06/27	05:30	TMM		Opened clay filter for 3 min.
2014/06/27	06:20	TMM	173H:23M 941 Acc Cycles	Checked test and transferred data Took fuel sample #22.
2014/06/27	15:08	TMM	182H:11M 989 Acc Cycles	Shut test down because of loss of P1 and Pb pressures. Investigation reveled loss of boost pressure was caused by running out of fuel in the sump; root cause was a blown heat exchanger.
2014/06/27				Review of data shows that around 11:00 am there was a loss of boost pressure.
2014/07/07	12:30	TMM	177H:23M 965 Acc Cycles	Reset the Run Time to (+4.0) and Acc Cycles to (+24) from the recorded log taken at 06:20 on 2014/06/27.
2014/07/08	06:20	TMM		Filled sump and ran clay filter for 30 min. Took fuel sample #23.
2014/07/09	05:05	TMM	177H:23M 965 Acc Cycles	Restarted test.
2014/07/09	06:20	TMM	178H:33M 972 Acc Cycles	Took pre test sample be saved until the report is written and sample #24.
2014/07/09	10:45	TMM	182H:51M 995 Acc Cycles	Took sample #25.

Event Log

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
2014/07/09	14:25	TMM	186H:32M 1015 Acc Cycles	Took sample #26.
2014/07/09	18:46	JW	190H:54M 1039 Acc Cycles	Took sample #27.
2014/07/10	06:10	TMM	202H:22M 1101 Acc Cycles	Checked test and transferred data. Took fuel sample #28.
2014/07/10	13:50	TMM	209H:55M 1142 Acc Cycles	Opened clay filter for 3 min.
2014/07/10	18:45	JW	214H:51M 1169 Acc Cycles	Took sample #29.
2014/07/11	06:05	TMM	226H:20M 1230 Acc Cycles	Checked test and transferred data Took fuel sample #30.
2014/07/11	12:20	TMM	232H:37M 1265 Acc Cycles	Opened clay filter for 6 min.
2014/07/11	18:51	JW	239H:04M 1300 Acc Cycles	Took sample #31.
2014/07/12	06:15	TMM	250H:027 1362 Acc Cycles	Checked test and transferred data. Took sample #32.
2014/07/12	18:45	BW	263H:01M 1430 Acc Cycles	Took sample #33.
2014/07/13	06:35	MJN	274H:45M 1494 Acc Cycles	Took sample #34.
2014/07/13	18:30	KLK	286H:40M 1556 Acc Cycles	Took sample #35.
2014/07/14	06:10	TMM	298H:22M 1622 Acc Cycles	Checked test and transferred data. Took sample #36.
2014/07/14	18:45	JW	310H:56M 1690 Acc Cycles	Took sample #37.

Event Log

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
2014/07/15	06:15	TMM	322H:39M 1753 Acc Cycles	Checked test and transferred data. Took sample #38.
2014/07/15	09:45	TMM	325H:50M 1771 Acc Cycles	Opened clay filter for 5 min.
2014/07/15	19:15	JW	334H:53M 1820 Acc Cycles	Took sample #39.
2014/07/16	06:15	TMM	346H:27M 1883 Acc Cycles	Checked test and transferred data. Took sample #40.
2014/07/16	18:45	JW	358H:51M 1950 Acc Cycles	Took sample #41.
2014/07/17	06:25	TMM	370H:34M 2014 Acc Cycles	Checked test and transferred data. Took sample #42.
2014/07/17	11:00	TMM	375H:34M 2039 Acc Cycles	Opened clay filter for 3 min.
2014/07/17	18:43	JW	382H:48M 2080 Acc Cycles	Took sample #43.
2014/07/18	06:12	TMM	394H:21M 2143 Acc Cycles	Checked test and transferred data. Took sample #44.
2014/07/18	13:00	TMM	401H:M14M 2180 Acc Cycles	Completed 400 hr low lube test. Took sample #45 and a sample to be saved until the report is written.

Equipment List

Table 4 - Equipment List

Test Stand/Cell: 2519	Recorded By: T. McCARTHY	Date: 2014-06-16
Test Article I/N: 6970-034	Test Article S/N: 19366491	

Qty	Test Hardware	Model Number	Serial Number	Calibration Due Date	Equip Used for: (DTP Para #)
1	0-500 PPTR		3118690	9-30-14	P1 TABLE 2
1	0-1500 PPTR		3548427	9-30-14	P1 TABLE 2
1	TORQUE 0-500 HIMMOSTINE METER	79550V	0-100 45110107	5-31-15	TORQUE LOW TABLE 2
1	0-500 HIMMOSTINE TORQUE METER	79550V	100-500 45110107	5-31-15	TORQUE HIGH TABLE 2

APPENDIX B – Low Lube Checklist

LOW LUBE OPERATIONAL TEST CHECKLIST

No.	Responsible	Signature	Date	Phase
1				**Preparation Phase**
1.1	Engr.		2014 06-17	Review EM 45.1.1 Engineering Checklist for Planning SOT
1.2	Engr. / Lab.		2014 06-17	Review EM 45.1.3 SOT Guidelines
2				**Assembly and Calibration 100 Hr Phase**
2.1	Lab.		2014-06-05	Has pump been tested per COM-852?
2.2	Lab.		2014 06-02	Are all critical inspections and photos completed and engineering informed of any anomalies?
2.3	Lab.		2014 06-05	Check breakaway torque on pump.
2.4	Engr.		2014 06-02	Has engineering reviewed critical inspection record and any hardware anomalies?
2.5	Lab.		2014 06-17	Is paperwork complete per OP-571?
2.6	Engr.		2014 06-06	Has ATP data been reviewed by engineering?
2.7	Engr.		2014 06-06	Has pump COM and other applicable test data been reviewed by engineering?
2.8	Lab.		2014 06-05	Has production test stand been calibrated and tagged to prevent tampering until Low Lube is completed?
3				**Low Lubricity Fuel Endurance Test 100 Hr Phase**
3.1	Lab.		2014 06-17	Is correct test fuel in sump tank, including additives if required?

LOW LUBE OPERATIONAL TEST CHECKLIST

No.	Responsible	Signature	Date	Phase
3.2	Lab.		2014 06-12	Have arrangements been made for low lubricity (BOCLE) checks?
3.3	Engr. / Lab.		2014 06-12	Has frequency of fuel samples and BOCLE checks been agreed upon with engineering?
3.4	Lab.		2014 06-18	Is test hardware installed as specified in the test plan?
3.5	Lab.		2014 06-18	Has Environmental Test Set-up Checklist (F25964) been completed (F27760 for outside tests houses)?
3.6	Lab.		2014 06-12	Has functional or operational hardware (slave unit) been used to check out test set-up?
3.7	Lab.		2014 06-12	Has test set-up been checked for proper plumbing, pressure taps, leaks, flow meter operation, etc?
3.8	Lab.		2014 06-14	Is equipment list completed?
3.9	Lab.		2014 06-12	Has test cell instrumentation been calibrated?
3.10	Engr.		2014 06-18	Is test hardware installed as specified in the test plan?
3.11	Engr.		2014 06-18	Is test cycle program set-up as defined in the test plan?
3.12	Lab.		2014 06-18	Have time clocks on equipment been synchronized (i.e. data recorder, cycle computer, etc.) and does nomenclature (Ps, Tin, etc) match the DTP?
3.13	Engr.		2014 06-18	Have interlocks been reviewed?
3.14	Engr. / Lab.		2014 06-18	Has a correlation check against ATP data been completed using the test article?
3.15	Lab.		2014 06-17	Has pre-test fuel sample been taken?

Footer Notes

LOW LUBE OPERATIONAL TEST CHECKLIST

No.	Responsible	Signature	Date	Phase
3.16	Lab.		2014 06-12	Are all set-up photographs with the unit installed completed? Photos should be adequate to allow the test set-up to be reconstructed?
3.17	Lab.		2014 -06-23	Has post-test fuel sample been taken?
3.18	Engr.		2014 06-24	Has endurance data, event log, and photos been reviewed by engineering?
3.19	Lab.		2014 06-23	Has post-test ATP been completed?
3.20	Engr.		2014 06-24	Has post-test ATP data been reviewed by engineering?
3.21	Lab./ Engr.		2014 06-24	Has the pump been disassembled, inspected and photos taken?
3.22	Lab. / Engr.		2014 06-24	Have all critical inspections been completed as applicable and photos been obtained (if applicable as decided by engineering)?
3.23	Lab./Engr.		2014 06-24	Engineering reviewed and approved reassembled ATP data (if applicable)?
4				**Disassembly and Inspection 100 Hr Phase**
4.1	Lab.		2014 06-24	Is COM 852 complete?
4.2	Engr.		2014 06-24	Has ATP data been reviewed by engineering?
4.3	Engr.		2014 06-24	Has COM data and other testing data been reviewed by engineering?
4.4	Engr. / Lab.		2014 06-24	Are special tests/investigations complete?
4.5	Lab. / Engr.		2014 06-24	Have all critical inspections and photos been obtained?
4.6	Engr.		2014 06-24	Have inspection results, event log, and photos been reviewed by engineering?

Footer Notes

LOW LUBE OPERATIONAL TEST CHECKLIST

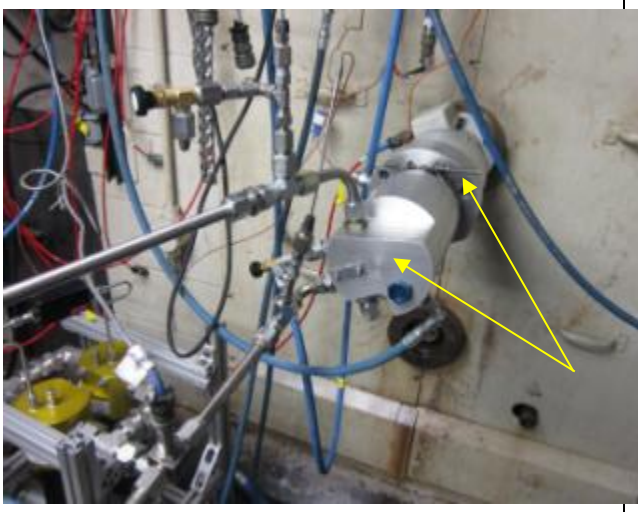
No.	Responsible	Signature	Date	Phase
5				**Assembly and Calibration - 300 Hr Phase**
5.1	Lab.		2014 06-24	Has pump been tested per COM-852?
5.2	Lab.		2014 06-24	Are all critical inspections and photos completed and engineering informed of any anomalies?
5.3	Lab.		2014 06-24	Check breakaway torque on pump.
5.4	Engr.		2014 06-24	Has engineering reviewed critical inspection record and any hardware anomalies?
5.5	Lab.		2014 06-24	Is paperwork complete per OP-571?
5.6	Engr.		2014 06-24	Has ATP data been reviewed by engineering?
5.7	Engr.		2014 06-24	Has pump COM and other applicable test data been reviewed by engineering?
5.8	Lab.		2014 06-24	Has production test stand been calibrated and tagged to prevent tampering until Low Lube is completed?
6				**Low Lubricity Fuel Endurance Test 300 Hr Phase**
6.1	Lab.		2014 06-24	Is correct test fuel in sump tank, including additives if required?
6.2	Lab.		2014 06-24	Have arrangements been made for low lubricity (BOCLE) checks?
6.3	Engr. / Lab.		2014 06-24	Has frequency of fuel samples and BOCLE checks been agreed upon with engineering?

(Some information was removed due to proprietary content)

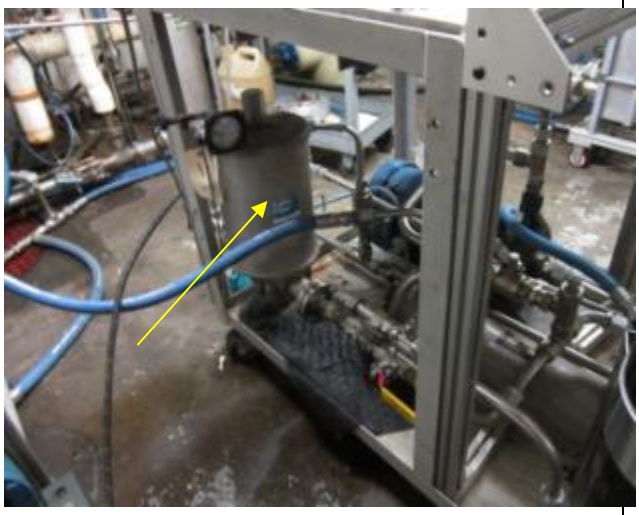
Appendix D

Setup Photographs

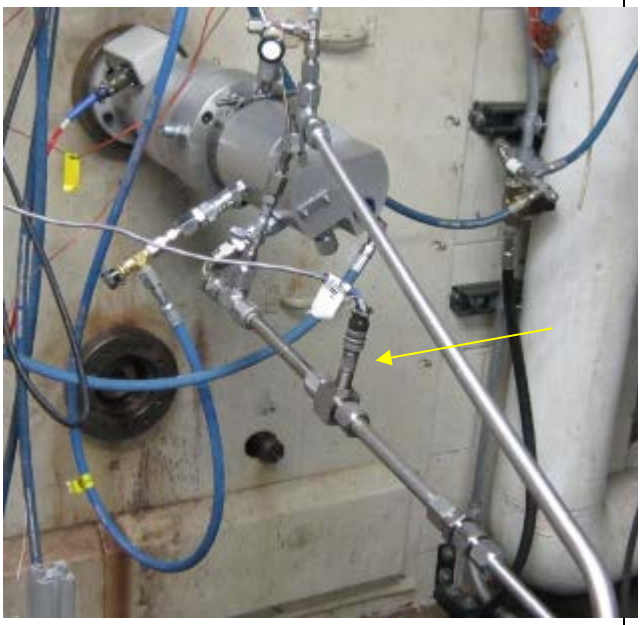
Low Lube Set Up: Supply Tank & Clay Filter (on left)



Test Unit in Test Block on Drive Pad.



Fuel Filter



Flow Meter

	
Heat exchanger and boost pump	**Pressure control valve and burst disk**

Appendix E

Low Lubricity Data

Table 5 - Lubricity Test Results

Sample	Date	Time	Accred Cycles	Accred Hours	Lubricity
1	18-June-2014	1500	0	0	0.97
2	18-June-2014	1530	3	.5	---
3	18-June-2014	1930	27	4.5	0.90
4	18-June-2014	2330	39	8.5	---
5	19-June-2014	0230	57	12.5	---
6	19-June-2014	0715	84	16.25	0.96
7	19-June-2014	1936	154	29.6	---
8	20-June-2014	0731	220	39.37	0.85
9	20-June-2014	1040	237	43.63	0.92
10	20-June-2014	2015	289	53.18	---
11	21-June-2014	0735	350	65.48	0.96
12	21-June-2014	1950	417	76.8	---
13	22-June-2014	0830	482	88.82	0.95
14	22-June-2014	1908	540	100.03	---
15	23-June-2014	0628	604	111.23	0.95
16	24-June-2014	1215	605	111.48	0.81
17	24-June-2014	1535	605	111.48	0.94
18	25-June-2014	0620	681	125.47	0.91
19	25-June-2014	1828	747	137.62	---
20	26-June-2014	0615	810	149.27	0.91
21	26-June-2014	1817	875	161.23	---
22	27-June-2014	0620	941	173.38	0.96
23	8-July-2014	0620	965	177.38	0.96
24	9-July-2014	0620	972	178.55	0.95
25	9-July-2014	1045	995	182.85	---
26	9-July-2014	1425	1015	186.53	0.92

27	9-July-2014	1846	1039	190.9	---
28	10-July-2014	0610	1101	202.37	0.90
29	10-July-2014	1845	1169	214.85	---
30	11-July-2014	0605	1230	226.33	0.90
31	11-July-2014	1851	1300	239.07	---
32	12-July-2014	0615	1362	250.45	0.93
33	12-July-2014	1845	1430	263.02	---
34	13-July-2014	0635	1494	274.75	0.92
35	13-July-2014	1830	1556	286.67	---
36	14-July-2014	0610	1622	298.37	0.92
37	14-July-2014	1845	1690	310.93	---
38	15-July-2014	0615	1753	322.65	0.90
39	15-July-2014	1915	1820	334.88	---
40	16-July-2014	0615	1883	346.45	0.95
41	16-July-2014	1845	1950	358.85	---
42	17-July-2014	0625	2014	370.57	0.94
43	17-July-2014	1843	2080	382.8	---
44	18-July-2014	0612	2143	394.35	0.91
45	18-July-2014	1300	2180	401.23	0.92

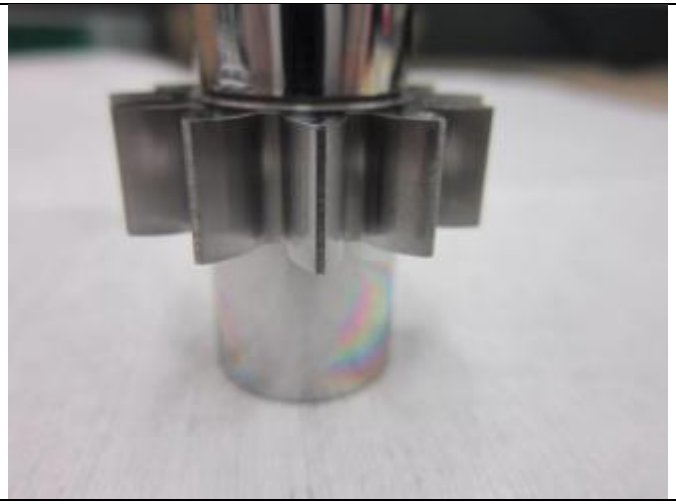
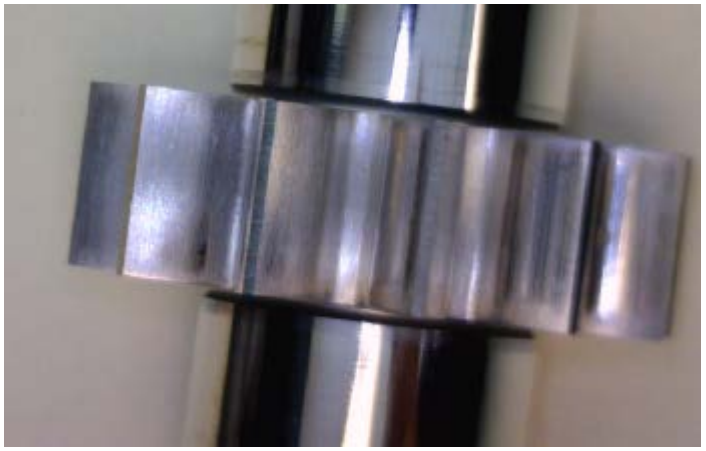
Appendix F

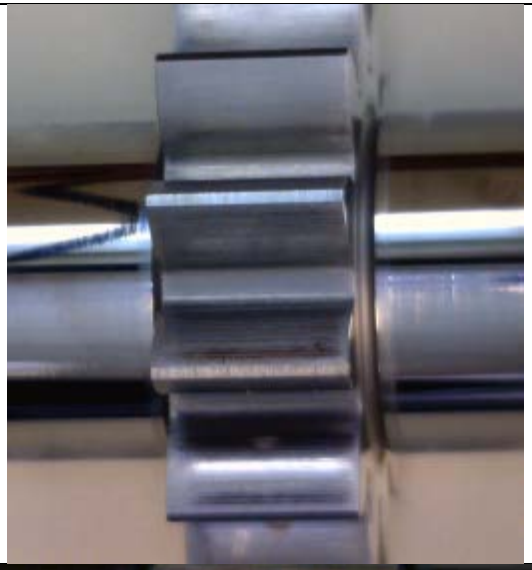
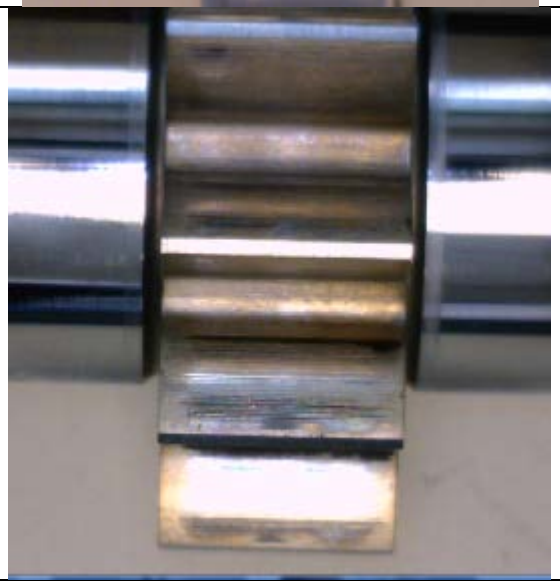
Pre and Post Test Inspection Photos

All-Inclusive View of CT7/T700

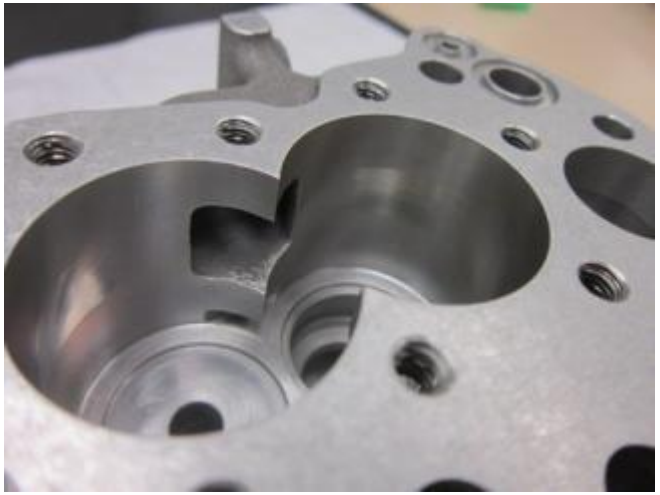
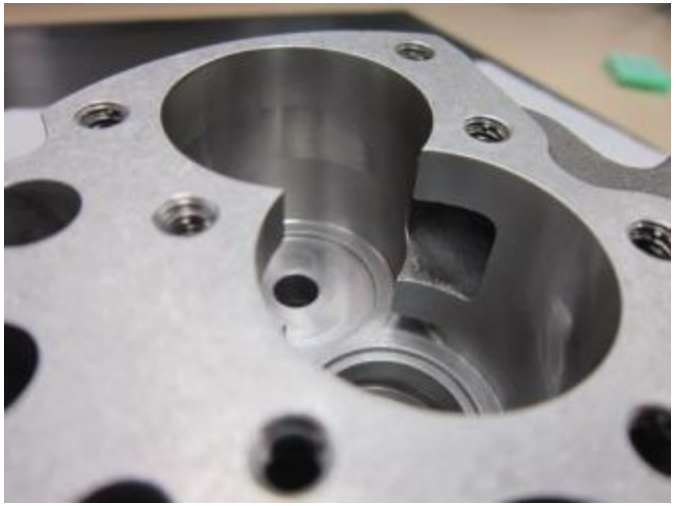
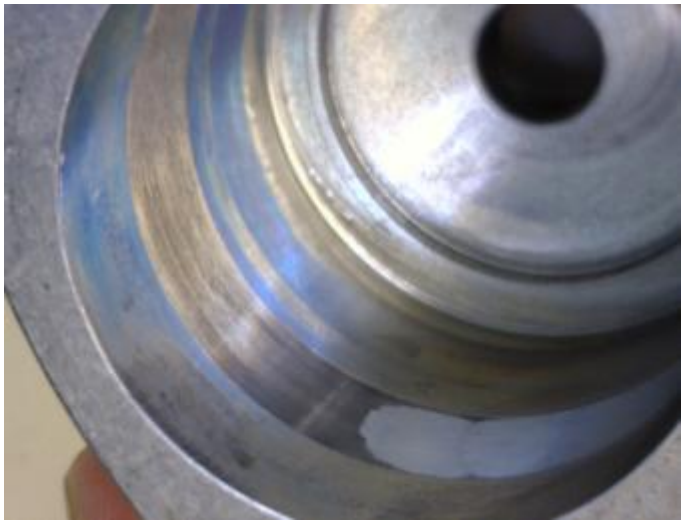
Pre Test	Post Test	Notes
Image 1: Floating Bearings		
		Floating bearings show fair polishing after 400 hrs.
		Floating bearings show no significant clipping.
Image 2: Stationary Bearings		

Pre Test	Post Test	Notes
		Stationary bearings show fair polishing after 400 hrs.
		Stationary bearings show no significant clipping.

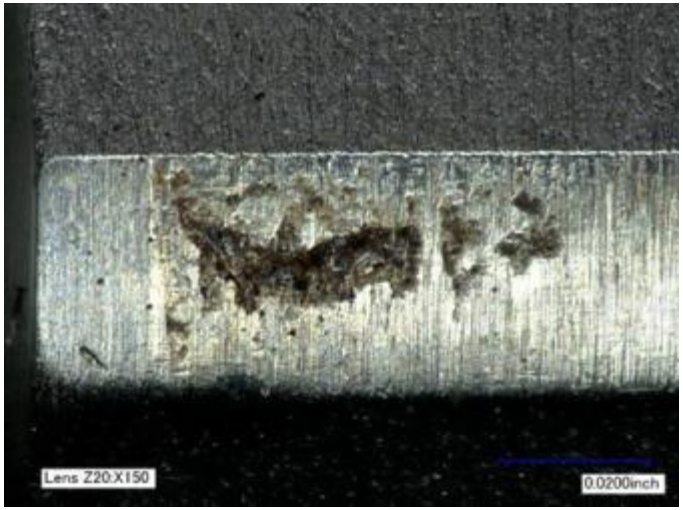
Pre Test	Post Test	Notes
		Stationary bearing faces show fair polishing after 400 hrs.
Image 3: Gear Set		
		Idler gear shows typical wear and cavitation with polished gear teeth on working side.

Pre Test	Post Test	Notes
		
		Driven gear shows typical wear and cavitation. Gear teeth polished on working side.

Pre Test	Post Test	Notes
		
Image 4: Housing Bores		
		Housing inlet: bore is wiped completely around the inside diameter of both the driven and idler gear bore.

Pre Test	Post Test	Notes
		Housing drive bearing bore.
		Housing driven bearing bore.

Pre Test	Post Test	Notes
		Housing discharge bore.
Image 5: HPRV		
		HPRV shows no signs of significant wear.

Pre Test	Post Test	Notes
		Several edges show signs of a deposited organic substance. Post performance of HPRV showed no significant issues.
		Close up view of the deposit.

Appendix G

Intermediate Checks

Post 100-hr COM-852, CCP Acceptance Test

WOODWARD GOVERNOR COMPANY
ROCKFORD, IL
CAGE 66503

COM-852
ECL: D
PAGE : 1 OF 1

Desc: COM - CCP ACCEPTANCE TEST PROCEDURE
Date: 22-JUL-2014
IMTPC - TEST SPECIFICATION RESULTS PRINT REPORT

Serial No: 19366491 Run No: 3 Work Order: 1799810 Item No: 6970-034
Current Status: A Run Status: P Test Type: AR Test Date: 23-JUN-2014

Test Point		Record	Units	Formula Tag	Min	Value	Max	Pass Fail
1.0	Total Flow Rate Check							
1.1	Record Qtotal	Qtotal	gpm	QTOT_1	3.76	4.45	6.00	P
2.0	HPRV Total Flow Bypass	(Ps-Pb1)	psid		900	972	1070	P
3.0	HPRV Reseating Check							
3.1	Record Qtotal	Qtotal	gpm		4.19 (Calc)	4.38	4.71 (Calc)	P
4.0	Total Flow Rate Check							
4.1	Record Qtotal	Qtotal	gpm	QTOT_2	8.50	10.27		P
5.0	HPRV Near Cracking Pressure Check							
5.1	Record Qtotal	Qtotal	gpm		9.75 (Calc)	10.14	10.79 (Calc)	P
6.0	HPRV Total Flow Bypass	(Ps-Pb1)	psid		900	969	1120	P
7.0	HPRV Reseating Check							
7.1	Record Qtotal	Qtotal	gpm		10.01 (Calc)	10.26	10.53 (Calc)	P
8.0	Starting Flow Rate Check							
8.1	Record Qtotal	Qtotal	gpm		0.85	1.07	1.50	P
9.0	Max Flow Check							
9.1	Record Qtotal	Qtotal	gpm		8.03	9.48		P
10.0	Leakage Check							
10.1	Record External Leakage	Ext Leakage	drops/min		0.0	0.0	0.0	P
10.2	Record OBD Leakage	OBD Leakage	drops/min		0.0	0.0	0.0	P
11.0	Breakaway Torque Check	Tq	lb_in			6	15	P

The following criteria were used to run this report:
Serial No: 19366491
Run Number: 3
Status: A
Run Type: AR
Order By: 1

****
* End of IMTPC *
****

Post-177 hr COM-852, CCP Acceptance Test

WOODWARD GOVERNOR COMPANY
ROCKFORD, IL
CAGE 66503

COM-852
ECL: D
PAGE : 1 OF 1

Desc: COM - CCP ACCEPTANCE TEST PROCEDURE
Date: 22-JUL-2014
IMTPC - TEST SPECIFICATION RESULTS PRINT REPORT

Serial No: 19366491 Run No: 5 Work Order: 1895175 Item No: 6970-034
Current Status: A Run Status: F Test Type: AR Test Date: 30-JUN-2014

Test Point		Record	Units	Formula Tag	Min	Value	Max	Pass Fail
1.0	Total Flow Rate Check							
1.1	Record Qtotal	Qtotal	gpm	QTOT_1	3.76	4.09	6.00	P
2.0	HPRV Total Flow Bypass	(Ps-Pb1)	psid		900	1200	1070	FAIL
3.0	HPRV Reseating Check							
3.1	Record Qtotal	Qtotal	gpm		3.83 (Calc)	4.05	4.35 (Calc)	P
4.0	Total Flow Rate Check							
4.1	Record Qtotal	Qtotal	gpm	QTOT_2	8.50	9.88		P
5.0	HPRV Near Cracking Pressure Check							
5.1	Record Qtotal	Qtotal	gpm		9.36 (Calc)	9.78	10.40 (Calc)	P
6.0	HPRV Total Flow Bypass	(Ps-Pb1)	psid		900	1200	1120	FAIL
7.0	HPRV Reseating Check							
7.1	Record Qtotal	Qtotal	gpm		9.62 (Calc)	9.92	10.14 (Calc)	P
8.0	Starting Flow Rate Check							
8.1	Record Qtotal	Qtotal	gpm		0.85	0.93	1.50	P
9.0	Max Flow Check							
9.1	Record Qtotal	Qtotal	gpm		8.03	9.15		P
10.0	Leakage Check							
10.1	Record External Leakage	Ext Leakage	drops/min		0.0	0.0	0.0	P
10.2	Record OBD Leakage	OBD Leakage	drops/min		0.0	0.0	0.0	P
11.0	Breakaway Torque Check	Tq	lb_in			6	15	P

The following criteria were used to run this report:
Serial No: 19366491
Run Number: 5
Status: A
Run Type: AR
Order By: 1

****
* End of IMTPC *
****

Post-100 hr Inspection Data

CRITICAL INSPECTION RECORD – POST-TEST 100 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
N/A	Breakaway Torque	6	Jason Long 2014-06-23
Packing			
Ps Discharge (182748)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
Vapor Vent (182650)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
Overboard Drain (182650)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
Cartridge Seal (182574)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
Drive Floating Bearing (182625)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
Driven Floating Bearing (182625)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
HPRV (182748)	Visual	No discrepancies	ErinRay Meyer 2014-06-23

CRITICAL INSPECTION RECORD – POST-TEST 100 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
Springs			
Floating Bearing Springs (1520-1423)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
HPRV Spring (1524-646)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
Bearings/Gears			
Drive Floating Bearing (1401-1175)	Visual	Light polishing	ErinRay Meyer 2014-06-23
	Inner Diameter	0.6954	Craig Rolander 2014-06-24
	Height	0.3632	Craig Rolander 2014-06-24
Driven Floating Bearing (1401-1176)	Visual	Light polishing	ErinRay Meyer 2014-06-23
	Inner Diameter	0.6954	Craig Rolander 2014-06-24
	Height	0.3631	Craig Rolander 2014-06-24
Drive Stationary Bearing (1401-1174)	Visual	Light polishing	ErinRay Meyer 2014-06-23
	Inner Diameter	0.6954	Craig Rolander 2014-06-24
	Height	0.5400	Craig Rolander 2014-06-24
Driven Stationary Bearing (1401-1174)	Visual	Light polishing	ErinRay Meyer 2014-06-23
	Inner Diameter	0.6953	Craig Rolander 2014-06-24
	Height	0.5401	Craig Rolander 2014-06-24
* Drawing Limits on all bearing inner diameters are .6952" - .6957"			

CRITICAL INSPECTION RECORD – POST-TEST 100 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
Drive Gear (1445-1135)	Visual (Including Journal and Face Finishes)	Minimal cavitation	ErinRay Meyer 2014-06-23
	Outer Diameter	1.25605	Steve Dietrich 2014-06-24
	Width	0.3752	Steve Dietrich 2014-06-24
	Front Journal OD	0.6941	Steve Dietrich 2014-06-24
	Rear Journal OD	0.6940	Steve Dietrich 2014-06-24
Driven Gear (1445-1135)	Visual (Including Journal and Face Finishes)	Minimal cavitation	ErinRay Meyer 2014-06-23
	Outer Diameter	1.2561	Steve Dietrich 2014-06-24
	Width	0.3752	Steve Dietrich 2014-06-24
	Front Journal OD	0.6941	Steve Dietrich 2014-06-24
	Rear Journal OD	0.6941	Steve Dietrich 2014-06-24
Both Gears	Gear Tooth Profile per Drawing (1445-1135) Instructions	Inspect all teeth; both faces, and overlay front and back face inspection charts for each tooth. Provide inspection records to engineering.	ErinRay Meyer 2014-06-23
* Drawing Limits on all outer gear diameters are 1.25575" – 1.25625"			
* Drawing Limits on all gear widths are .3747" - .3753"			
* Drawing Limits on all journal outer diameters are .69375" - .69425"			

CRITICAL INSPECTION RECORD – POST-TEST 100 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
Seals			
Cartridge Seal (3051-5051)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
Trapezoidal Seal (3051-5052)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
HPRV			
Sleeve (5225-1254)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
Piston (5225-1254)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
Spring Seat (4100-1179)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
Housing			
Pump Cover (3550-1584)	Visual	No discrepancies	ErinRay Meyer 2014-06-23
Pump Housing (4034-1630)	Visual	The housing wipe extends the entire inside diameter of each bore.	ErinRay Meyer 2014-06-23

Post-177 hr Inspection Data

APPENDIX A – Critical Inspection Record – POST 177 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
N/A	Breakaway Torque	8.5 (Running torque is 6)	Jason Long 2014-06-30
Packing			
Ps Discharge (182748)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
Vapor Vent (182650)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
Overboard Drain (182650)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
Cartridge Seal (182574)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
Drive Floating Bearing (182625)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
Driven Floating Bearing (182625)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
HPRV (182748)	Visual	No discrepancies	ErinRay Meyer 2014-06-30

CRITICAL INSPECTION RECORD – POST 177 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
Springs			
Floating Bearing Springs (1520-1423)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
HPRV Spring (1524-646)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
Bearings/Gears			
Drive Floating Bearing (1401-1175)	Visual	Fair polishing	ErinRay Meyer 2014-06-30
	Inner Diameter	0.6954	Craig Rolander 2014-07-01
	Height	0.3633	Craig Rolander 2014-07-01
Driven Floating Bearing (1401-1176)	Visual	Fair polishing	ErinRay Meyer 2014-06-30
	Inner Diameter	0.6954	Craig Rolander 2014-07-01
	Height	0.3631	Craig Rolander 2014-07-01
Drive Stationary Bearing (1401-1174)	Visual	Fair polishing	ErinRay Meyer 2014-06-30
	Inner Diameter	0.6954	Craig Rolander 2014-07-01
	Height	0.5400	Craig Rolander 2014-07-01
Driven Stationary	Visual	Fair polishing	ErinRay Meyer 2014-06-30

CRITICAL INSPECTION RECORD – POST 177 hrs

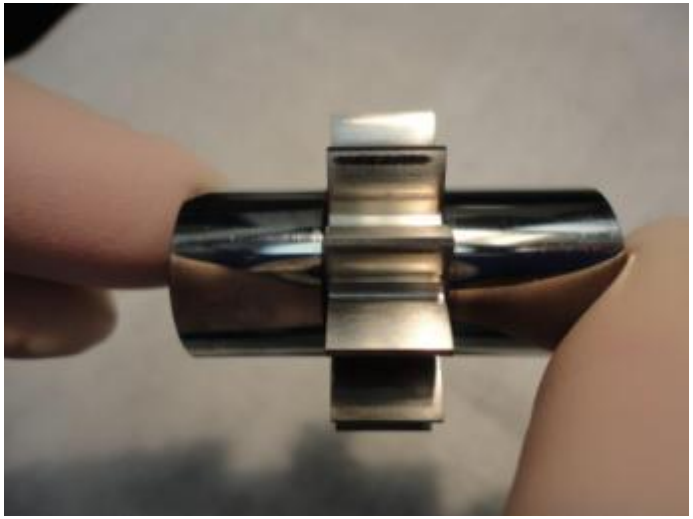
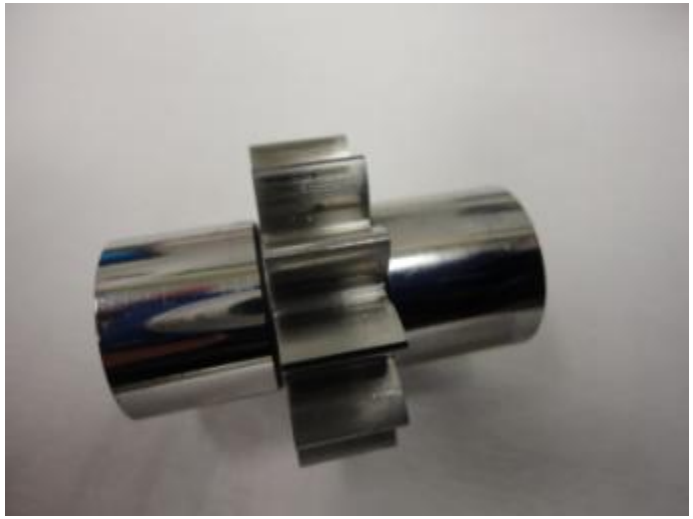
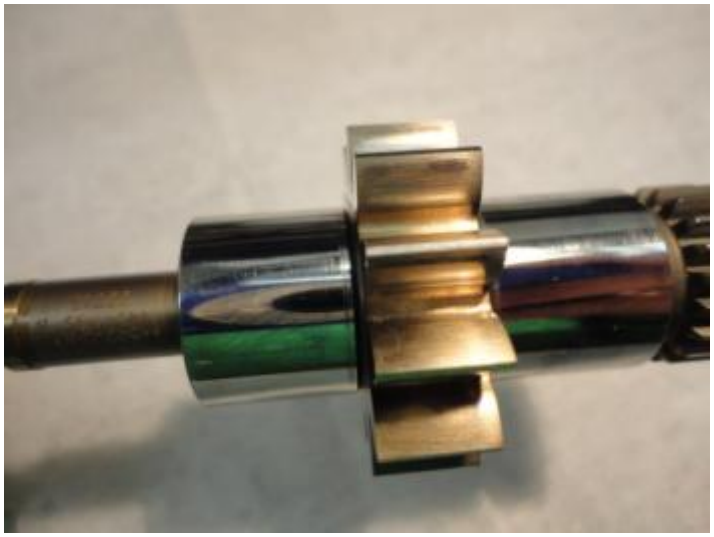
Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
Bearing (1401-1174)	Inner Diameter	0.6954	Craig Rolander 2014-07-01
	Height	0.5401	Craig Rolander 2014-07-01
* Drawing Limits on all bearing inner diameters are .6952" - .6957"			
Drive Gear (1445-1135)	Visual (Including Journal and Face Finishes)	Minimal cavitation and light markings on journals	ErinRay Meyer 2014-06-30
	Outer Diameter	1.25605	Steve Dietrich 2014-07-01
	Width	0.3752	Steve Dietrich 2014-07-01
	Front Journal OD	0.6941	Steve Dietrich 2014-07-01
	Rear Journal OD	0.6940	Steve Dietrich 2014-07-01
Driven Gear (1445-1135)	Visual (Including Journal and Face Finishes)	Minimal cavitation and light markings on journals	ErinRay Meyer 2014-06-30
	Outer Diameter	1.2561	Steve Dietrich 2014-07-01
	Width	0.3752	Steve Dietrich 2014-07-01
	Front Journal OD	0.6941	Steve Dietrich 2014-07-01
	Rear Journal OD	0.6941	Steve Dietrich 2014-07-01
* Drawing Limits on all outer gear diameters are 1.25575" – 1.25625"			
* Drawing Limits on all gear widths are .3747" - .3753"			
* Drawing Limits on all journal outer diameters are .69375" - .69425"			
Seals			

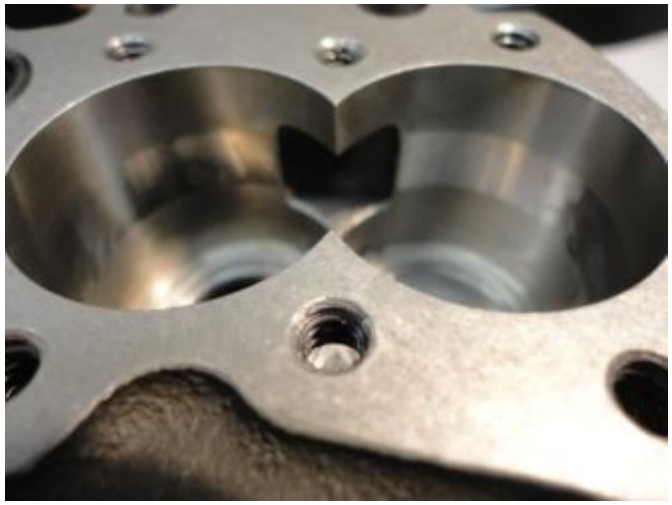
CRITICAL INSPECTION RECORD – POST 177 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	**Inspection**	**Record**	**Name and Date**
Cartridge Seal (3051-5051)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
Trapezoidal Seal (3051-5052)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
HPRV			
Sleeve (5225-1254)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
Piston (5225-1254)	Visual	Organic deposit on several edges	ErinRay Meyer 2014-06-30
Spring Seat (4100-1179)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
Housing			
Pump Cover (3550-1584)	Visual	No discrepancies	ErinRay Meyer 2014-06-30
Pump Housing (4034-1630)	Visual	The housing wipe extends the entire inside diameter of each bore.	ErinRay Meyer 2014-06-30

Post-100 hrs	Post-177 hrs	Notes
Image 1: Floating Bearings		
		Floating bearings show light polishing after 100 hours and fair polishing after 177.
		

Post-100 hrs	Post-177 hrs	Notes
Image 2: Stationary Bearings		
		Stationary bearing faces show light polishing after 100 hours and fair polishing after 177 hrs.
		

Post-100 hrs	Post-177 hrs	Notes
Image 3: Gear Set		
		Idler gear: shows typical wear and cavitation.
		Drive gear: shows typical wear and cavitation.

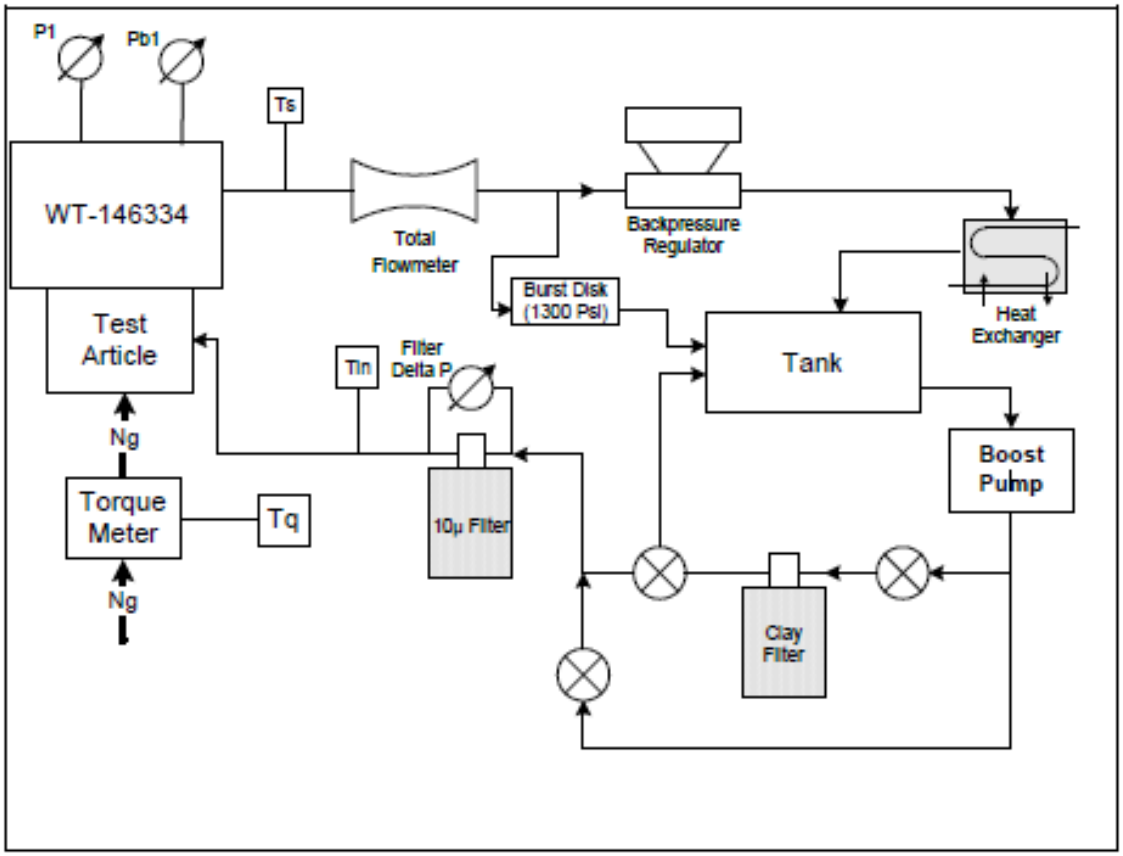
Post-100 hrs	Post-177 hrs	Notes
Image 4: Housing		
		Housing inlet: gear wipe extends the entire inner diameter of each bore.
		Housing discharge

Appendix H

Figures

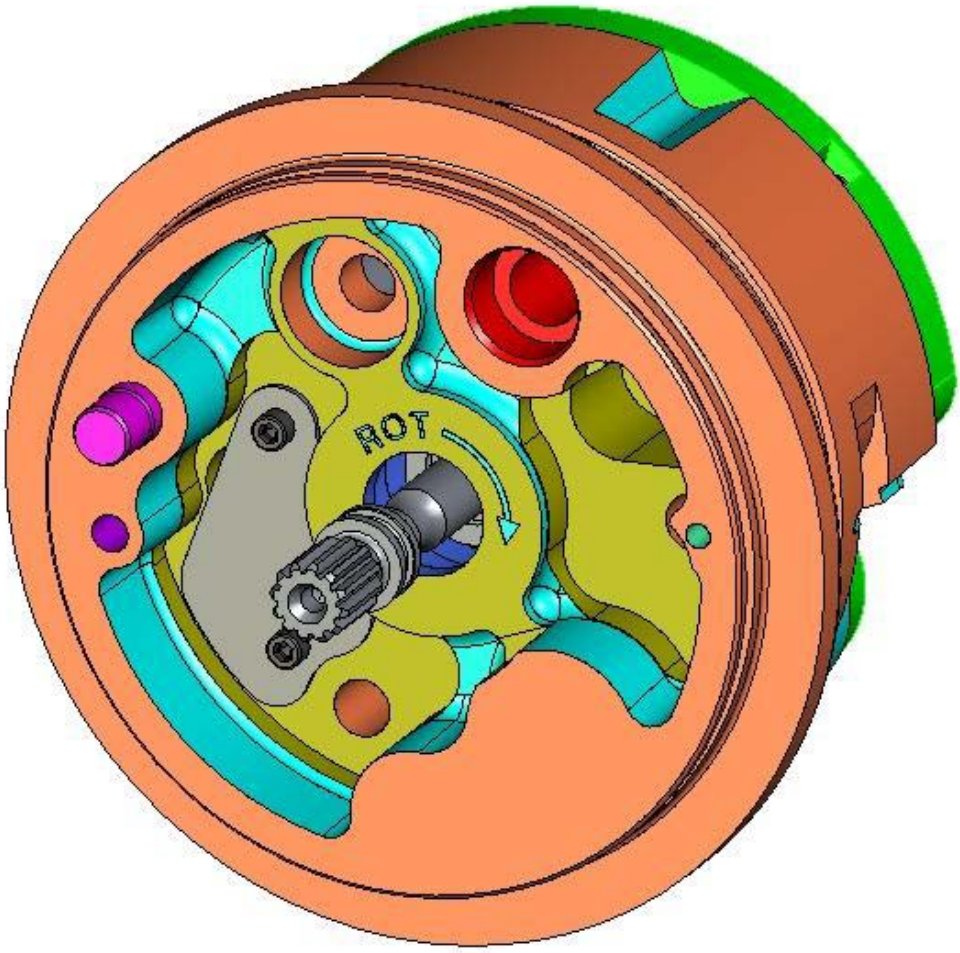
Test Schematic

Figure 1



Test Mounting Orientation

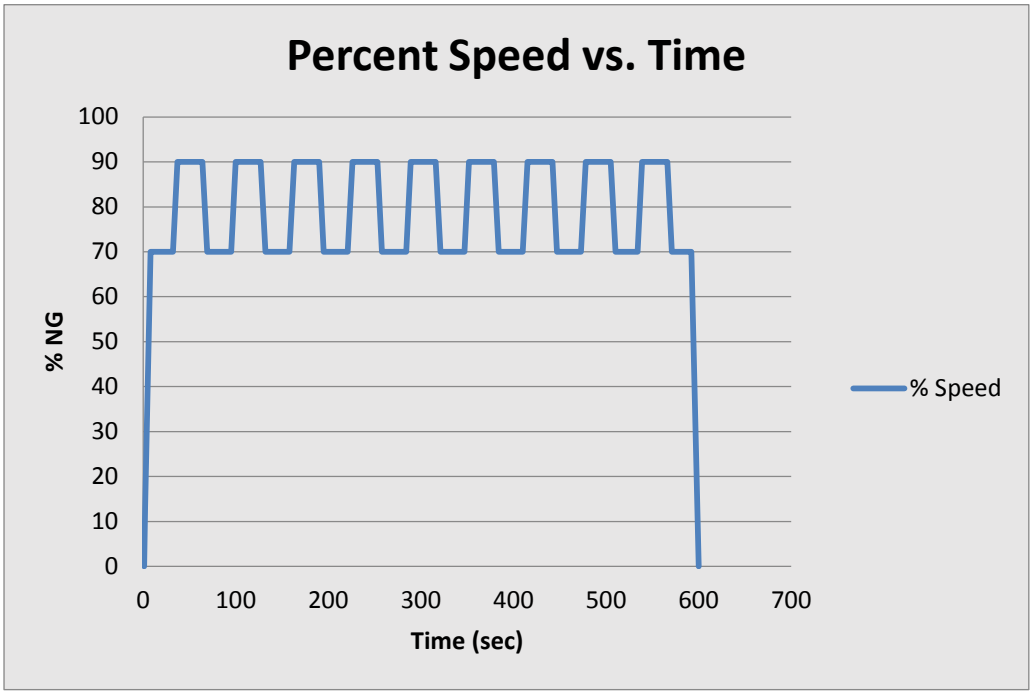
Figure 2



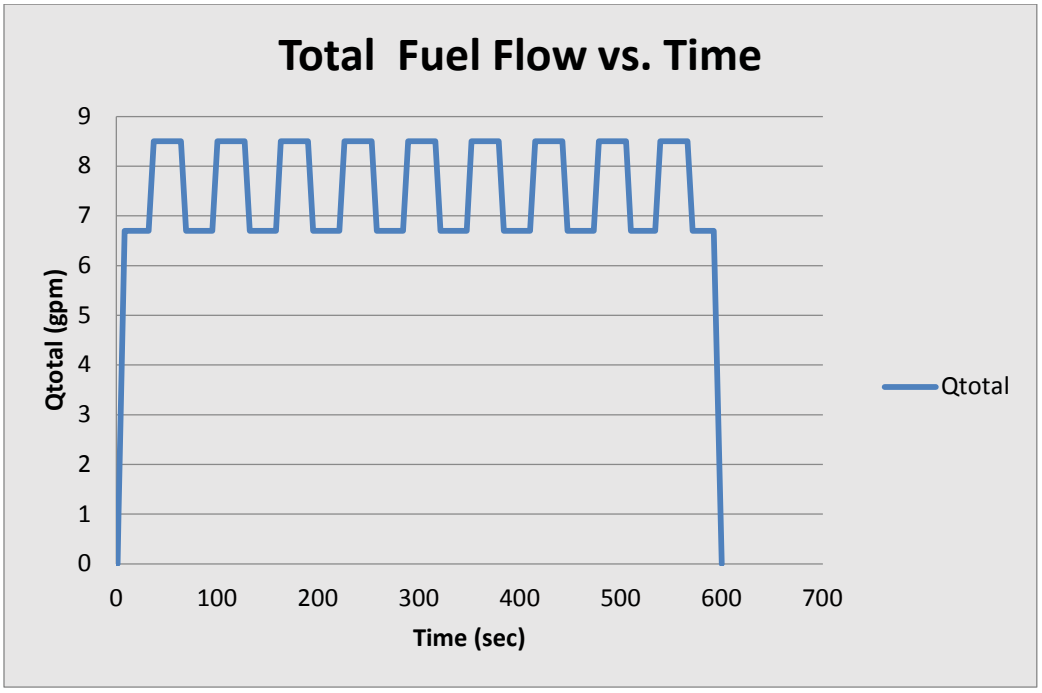
APPENDIX I

Mission Cycle

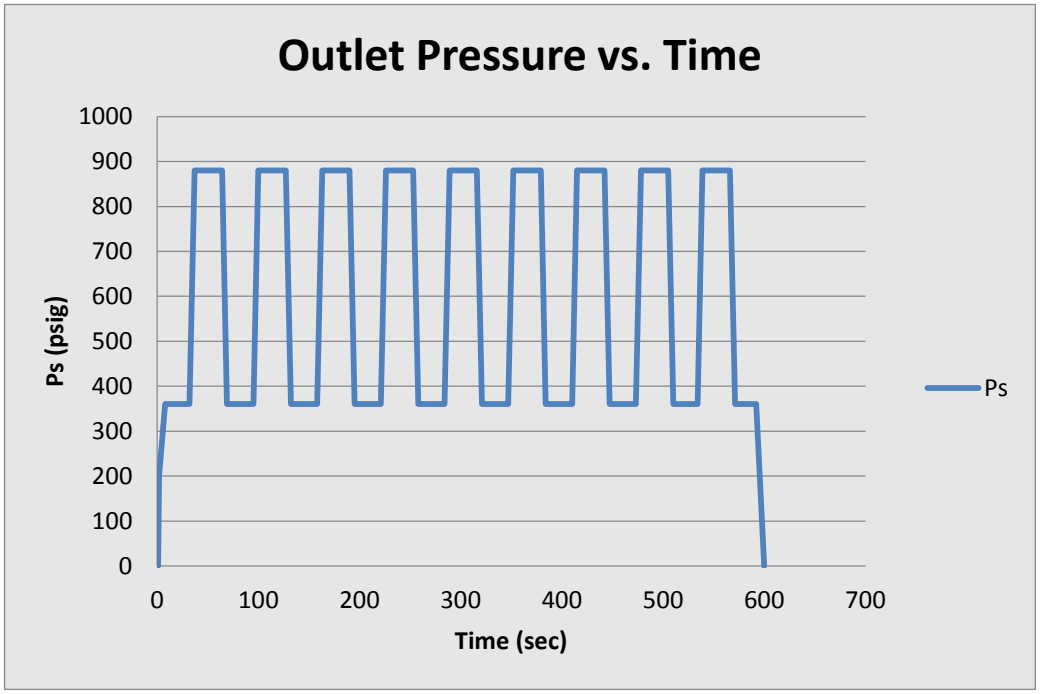
Test Cycle per Table 3; % Speed vs. Time



Test Cycle per Table 3; Fuel Flow vs. Time



Test Cycle per Table 3; Discharge Pressure vs. Time



List of Symbols, Abbreviations, and Acronyms

Symbols, Abbreviations, Acronyms	Description
AFRL	Air Force Research Laboratory
CCP	Commercial Cartridge Pump
DTIC	Defense Technical Information Center
PAO	Public Affairs Office
R&D	Research and Development
RQ	Aerospace Systems Directorate
RQT	Turbine Engine Division
RQTF	Fuels & Energy Branch